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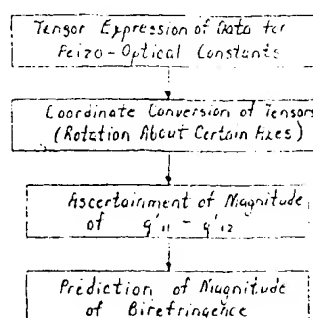
(54) Optical element made from fluoride single crystal and method of manufacturing the optical element

(57) The present invention provides a method for calculating the birefringence of an optical element and selecting the direction of minimum birefringence in the optical element. A material for manufacturing the optical element is a fluoride single crystal with a birefringence value that is reduced compared to conventional materials. The fluoride single crystal is cut from a fluoride single crystal ingot obtained by crystal growth so that the {111} crystal planes are two parallel planes, after which the optical performance is improved by subjecting this material to a heat treatment. The birefringence of the optical element is calculated by converting known piezo-optical constants in a specified three-dimensional orthogonal coordinate system for the optical material into piezo-optical constants in an arbitrary three-dimensional orthogonal coordinate system. The amount of change in the refractive index Δn_1 of the optical material in a first direction along the direction of one coordinate axis of the arbitrary three-dimensional orthogonal coordinate system, and the amount of change in the refractive index Δn_2 of the optical material in a second direction which is perpendicular to the first direction are calculated using a uniaxial stress that is applied to the optical material along the first direction and the piezo-optical constants in the arbitrary three-dimensional coordinate system. The amount of birefringence as seen from a third direction perpendicular to the first direction and the second direction is determined in the arbitrary three-dimensional orthogonal coordinate system by determining the dif-

ference between the amount of change in the refractive index Δn_1 and the amount of change in the refractive index Δn_2

Fig. 5

Algorithm for Predicting Value of Birefringence



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EUROPEAN SEARCH REPORT

Application Number
EP 99 10 4910

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Relevant to document with publication, where appropriate Citation of document with publication, where appropriate	Relevant to document with publication, where appropriate Citation of document with publication, where appropriate	CLASSIFICATION OF THE APPLICATION (Int. Cl. 6)
A	OLDHAM W G ET AL: "193-NM LITHOGRAPHIC SYSTEM LIFETIMES AS LIMITED BY UV COMPACTION" SOLID STATE TECHNOLOGY, COWAN PUBL CORP, WASHINGTON, US, vol. 40, no. 4, 1 April 1997 (1997-04-01), pages 98-99, 100, 1. XP000086899 ISSN: 0038-1110 * the whole document *	1-9	G02B1/02 G02B13/14 G02B5/30
A	US 5 031 977 A (GIESON JOHN A) 16 July 1991 (1991-07-16) * the whole document *	1-9	
A	CARODNA M ET AL: "Ellipsometric investigations of piezo-optical effects" THIN SOLID FILMS, ELSEVIER-SEQUOIA S.A., LAUSANNE, CH, vol. 313-314, 13 February 1998 (1998-02-13), pages 10-17, XP004132951 ISSN: 0040-6090 * the whole document *	1-8	TECHNICAL FIELDS SEARCHED (Int. Cl. 6) G02B
1A	M. BORN AND E. WOLF: "Principles of Optics, 6th edition, pages 703-705", PERGAMON PRESS, NEW YORK XP002178786 * the whole document *	1-9	

The present search report has been drawn up in the name of the

Name of search:

MUNICH

Date of completion of the search:

28 September 2001

lerbinger, K

CATEGORY OF CITED DOCUMENTS

- X: particularly relevant if taken alone
- Y: particularly relevant if combined with another document of the same category
- A: technological background
- (1): non-written disclosure
- (2): intermediate document

- 1: theory or principle underlying the invention
- 2: earlier patent document, but published on or after the filing date
- 3: document cited in the application
- 4: document cited for other reasons
- 5: member of the same patent family, corresponding document



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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 99 10 4916

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-9

A method for calculating the birefringence of an optical element or optical element material.

2. Claims: 10-14

An optical element which is constructed from a fluoride crystal, and the direction of the optical axis of the optical element substantially coincides with the $\langle 111 \rangle$ axial direction of the fluoride crystal, or substantially coincides with a direction perpendicular to the $\{111\}$ plane of the fluoride crystal.

3. Claims: 15-22

A method for manufacturing a material used for manufacturing optical elements, wherein the material is cut from a fluoride single crystal ingot obtained by crystal growth and subjected to a heat treatment, so that the $\{111\}$ crystal planes are two parallel planes, after which the optical performance is improved by subjecting the material to a heat treatment.

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO

EP 89 10 4916

This annex lists the patentable or novel features of the patent application in the form of a summarized European search report.
The information disclosed herein is contained in the European Patent Office (EPO) file.
The European Patent Office is not responsible for the accuracy of the information disclosed herein.

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Patent document number in search report	Publication date	Patent family number	Publication date
US 5531977	A	06-07-1991	NONE